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Abstract

Stockpiled bermudagrass [*Cynodon dactylon* (L.) Pers. 'Midland'] as a standing forage may meet nutritional needs of beef cows during winter. Our objective was to evaluate accumulation and nutritive value of fall stockpiled bermudagrass in response to N fertilization rate, N application date, and harvest date. Research was conducted near Burneyville, OK from 2000 to 2003. Fertilization rates included 0, 50, 100, and 150 lb N per acre applied on 15 August, 1 September, 15 September, 1 October, and 15 October. Forage accumulation was measured 10 days after the first killing frost; thereafter, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and total digestible nutrients (TDN) were assessed biweekly from 6 December to 20 February. An exceptionally hot and dry summer resulted in negligible forage production and unrepresentative forage quality in 2000. Forage accumulated linearly in 2001 and 2002 and quadratically in 2003 with N fertilization rate ($P \leq 0.05$). The dry matter averaged 56% TDN and 6.0, 6.9, 7.9, and 8.7% CP when N was applied at 0, 50, 100, and 150 lb/acre, respectively. The fertilized bermudagrass stands would have met CP and TDN requirements of mid-gestation beef cows had they been maintained on this forage.

Stockpiled Bermudagrass: A Low Cost Winter Feed

Strategies that extend the grazing season and reduce hay consumption during winter may increase profitability of beef cattle operations. In the southern United States, bermudagrass can be stockpiled and utilized as standing forage in the fall and winter. Fertilized stockpiled bermudagrass maintains adequate CP concentrations to meet nutritional needs of beef cows (7,8,10). Costs associated with the production and feeding of stockpiled bermudagrass have been estimated to be 57% of those associated with feeding hay (4). Despite these benefits, stockpiled bermudagrass experiences significant losses in nutritional value over winter (1,7,8) and may require use of supplements to maintain body weight and condition of spring-calving beef cows (10).

Accumulation and nutritive value of fall stockpiled bermudagrass have not been determined for southern Oklahoma nor has the effect of N application time been considered in previous studies (4). Agronomic management recommendations are frequently region and soil-specific. Our objective was to evaluate the effects of N fertilization rate, N application date, and winter harvest date on accumulation and nutritive value of fall stockpiled bermudagrass on a fine sandy loam soil in southern Oklahoma.

Experimental Procedures, Design, and Analysis

The research was conducted on a Minco fine sandy loam soil at the Noble Foundation Red River Demonstration and Research Farm near Burneyville, OK from 2000 to 2003. Burneyville, OK is located in Love Co., a county whose southern boundary is formed by the Red River separating Oklahoma and Texas. Adjacent counties to the east and west include Marshall and Jefferson counties, respectively. Fine sandy loam soils occupy 190,000 acres or 17% of the land area within these counties alone (9).

Treatments applied to 12 × 20-ft plots of ‘Midland’ bermudagrass included N fertilizer rates (0, 50, 100, and 150 lb/acre) and N application dates (15 August, 1 September, 15 September, 1 October, and 15 October). Before application of treatments each fall, the field plot area received a uniform application of 100 lb N per acre in the spring based on a forage yield goal of 2 tons/acre (3). The field plot area was then mowed at a 3-inch residue height and harvested for hay in June and in August. Phosphorous and K were applied to correct deficiencies according to soil tests each spring. Nitrogen was applied as ammonium nitrate.

Forage DM accumulation was measured once annually (27 November 2000, 7 December 2001, 6 December 2002, and 4 December 2003) through harvest of a 5 × 20-ft swath from the center of each plot at a 3-inch residue height using a HEGE 212 forage plot harvester (Wintersteiger Inc., Salt Lake City, UT). The annual forage harvest occurred approximately two weeks after the first killing frost (14 November 2000, 21 November 2001, 27 November 2002, and 24 November 2003). Nutritive value during winter was assessed from forage collected during the initial mechanized harvest and from samples hand-clipped to a 3-inch residue height from the remainder of each plot at 15-day intervals. Because the date of the first killing frost differed each year, the initial harvest and subsequent sample collection dates also differed each year. Forage samples were analyzed for CP, NDF, and ADF using wet chemistry techniques (Ward Laboratories, Kearney, NE). Nitrogen was determined by the Kjeldahl procedure. Neutral detergent fiber and ADF were determined by refluxing with neutral and acid detergent solutions, respectively. The neutral detergent solution contained a heat-stable amylase. Total digestible nutrients were computed from the equation: $\text{TDN} = 102.7 - (1.114 * \text{ADF})$.

The experiment was a randomized complete block design with a split-plot arrangement of N application dates as whole plots and N rates as subplots. Treatments were applied to the same plots each year; harvest date effects on nutritive value were considered repeated measures. Due to annual variation in rainfall, forage accumulation, and harvest dates, data were analyzed by year. The data were subjected to a repeated measures analysis of variance using the Mixed Models procedure in SAS (SAS Institute Inc., Cary, NC). Mean separations were calculated with least square means ($P \leq 0.05$).

Weather from 2000 to 2003

The weather differed each year of the experiment. Bermudagrass grows best when mean daily temperatures are above 75°F (2). In all four years, temperatures were suitable from August through October for fall forage accumulation (Table 1). Average high temperatures in August and September 2000, however, were 7° and 5°F, respectively, above the 50-year average high temperatures for the location. Precipitation was deficient during the falls of 2000 and 2003 (Fig. 1). Average annual precipitation across the last 50 years at Burneyville was 36 inches. Less than 1 inch of rain fell from July through September in 2000 compared to 8, 5, and 5 inches across this same period in 2001, 2002, and 2003, respectively. Precipitation was also 17 inches below the long-term annual average in 2003; the deficit occurred primarily from January through April and October through December.

Table 1. Average high and low temperatures from July-December recorded in 2000–2003, relative to the 50-year average at Burneyville, Oklahoma.

Year	Average	July	Aug	Sept	Oct	Nov	Dec
		Temperature (°F)					
2000	Low	72	72	62	58	37	27
	High	96	102	92	77	56	45
2001	Low	75	72	61	49	46	33
	High	97	95	83	75	68	57
2002	Low	70	71	63	51	36	32
	High	91	94	88	68	64	56
2003	Low	71	71	60	51	45	32
	High	98	98	83	81	67	59
50-year	Low	72	70	63	53	41	33
	High	95	95	87	77	65	56

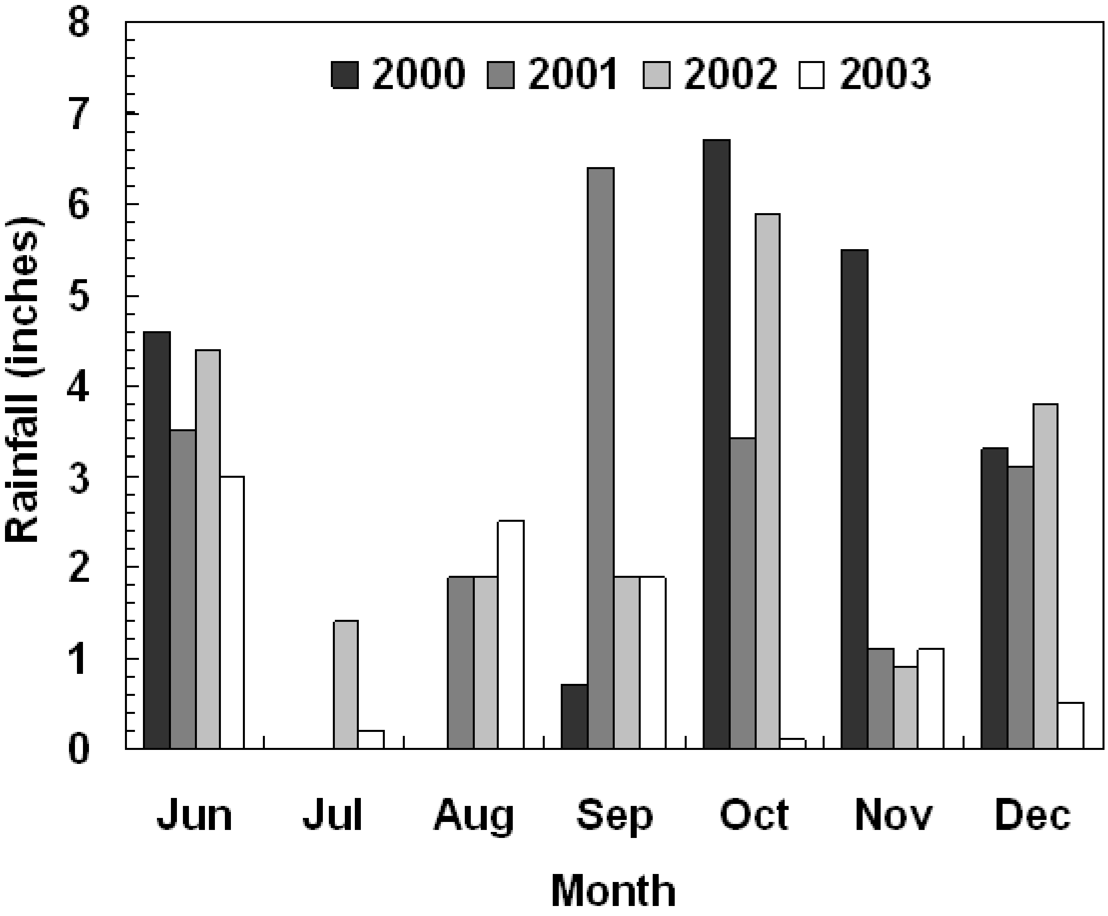

Fig. 1. June to December rainfall at Burneyville, OK, 2000 to 2003.

Nitrogen Fertilizer Rate and Application Date Effects

The exceptionally hot and dry conditions in 2000 resulted in negligible forage production and unrepresentative forage quality (*data not shown*). Consequently, results from 2001 to 2003 were used to describe treatment effects on bermudagrass. In 2001, 2002, and 2003, fall forage accumulation and nutritive value was primarily affected by N fertilizer rate and harvest date (Table 2). Interactions were mostly nonsignificant. Nitrogen fertilizer rate × harvest date and N rate × application date interactions affected CP in 2001 and 2003. In 2003, the application date × harvest date interaction was also significant for CP. In 2002, only the main effects of N fertilizer rate and harvest date were significant.

Table 2. Probability levels by year for effects of nitrogen rate, nitrogen application date, harvest date, and their interactions on dry matter (DM) accumulation and percentages of crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and total digestible nutrients (TDN) of stockpiled bermudagrass.

Year	**Source of variation**	**DM accumulated**	**CP**	**ADF**	**NDF**	**TDN**
		P > F				
2001	Nitrogen rate (N)	0.022	0.001	0.004	0.005	0.004
	Application date (D)	0.265	0.013	0.565	0.044	0.564
	N × D	0.273	0.009	0.493	0.089	0.502
	Harvest date (H)		0.088	0.002	0.001	0.002
	N × H		0.004	0.188	0.111	0.195
	D × H		0.457	0.606	0.696	0.623
	N × D × H		0.080	0.606	0.526	0.603
2002	Nitrogen rate (N)	0.136	0.001	0.030	0.002	0.031
	Application date (D)	0.449	0.629	0.475	0.471	0.474
	N × D	0.549	0.196	0.174	0.425	0.186
	Harvest date (H)		0.006	0.011	0.001	0.011
	N × H		0.256	0.836	0.160	0.821
	D × H		0.347	0.996	0.583	0.995
	N × D × H		0.876	0.516	0.257	0.501
2003	Nitrogen rate (N)	0.007	0.001	0.080	0.003	0.085
	Application date (D)	0.469	0.074	0.510	0.739	0.507
	N × D	0.828	0.003	0.009	0.688	0.008
	Harvest date (H)		0.002	0.104	0.001	0.103
	N × H		0.001	0.412	0.571	0.404
	D × H		0.033	0.883	0.304	0.886
	N × D × H		0.297	0.452	0.536	0.471

Forage accumulated linearly in 2001 and 2002 and quadratically in 2003 with N fertilization rate (Fig. 2) ($P \leq 0.05$). Across years, stockpiled bermudagrass production averaged 3450, 4000, 4170, and 4210 lb/acre at 0, 50, 100, and 150 lb N per acre, respectively. Nitrogen application date did not affect fall forage accumulation (Table 2). The date when stockpiling began was likely more important to forage accumulation than N application date (6). In southern Oklahoma, initiation of stockpiling in early August and application of N fertilizer by 15 October would enable forage to accumulate before a killing frost, provided rainfall is sufficient to support growth during this period.

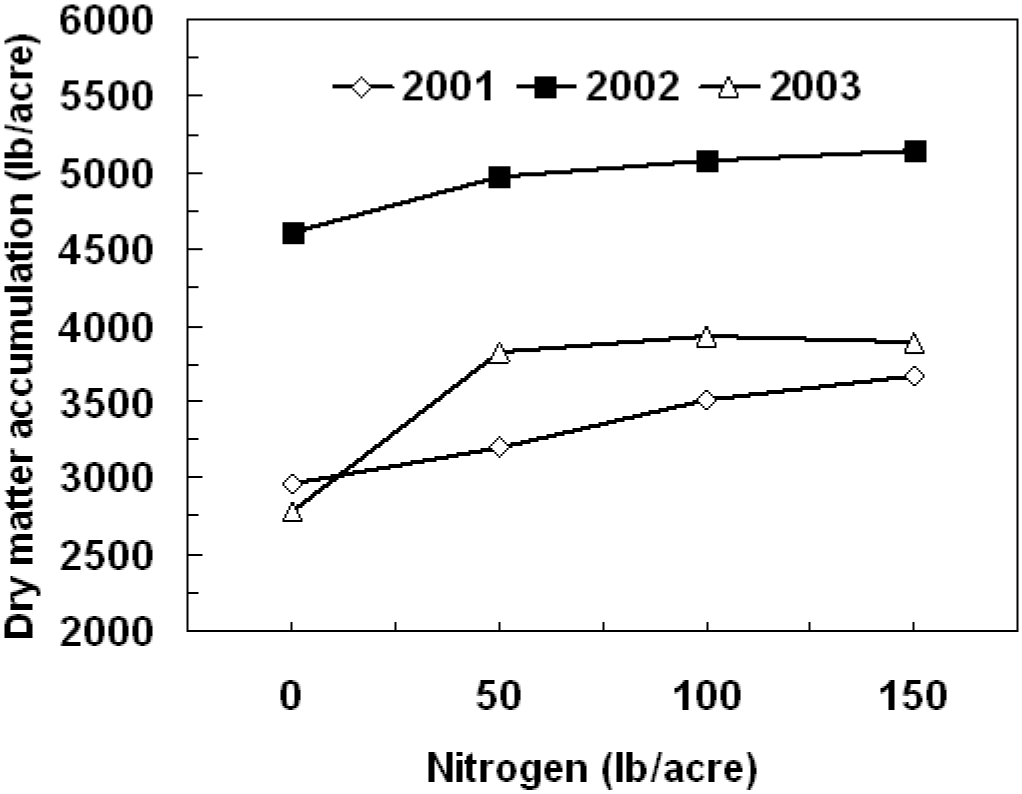

Fig. 2. Nitrogen fertilization rate effects on dry matter accumulation of stockpiled bermudagrass near Burneyville, OK on 7 December 2001, 6 December 2002, and 4 December 2003. Standard errors within each year were 190.3, 189.7, and 285.0, respectively. Values were computed across five nitrogen application dates and three replications (n = 15).

Forage nutritive value also increased with N fertilizer application (Fig. 3). Crude protein increased linearly with N fertilization rate each year ($P \leq 0.001$). Although N fertilizer rate × application date interactions occurred in 2001 and 2003, CP was stable across application dates (*data not shown*). Acid detergent fiber decreased quadratically in 2001 ($P \leq 0.05$) and linearly in 2002 ($P \leq 0.01$) with N fertilization rate but was not affected in 2003. Responses of TDN to N fertilization rate were opposite that of ADF. Nitrogen fertilization rate increased TDN quadratically in 2001 ($P \leq 0.05$), linearly in 2002 ($P \leq 0.01$), but had no effect in 2003. Neutral detergent fiber decreased linearly with N fertilization rate in 2001 and 2002 ($P \leq 0.001$) and quadratically in 2003 ($P \leq 0.05$).

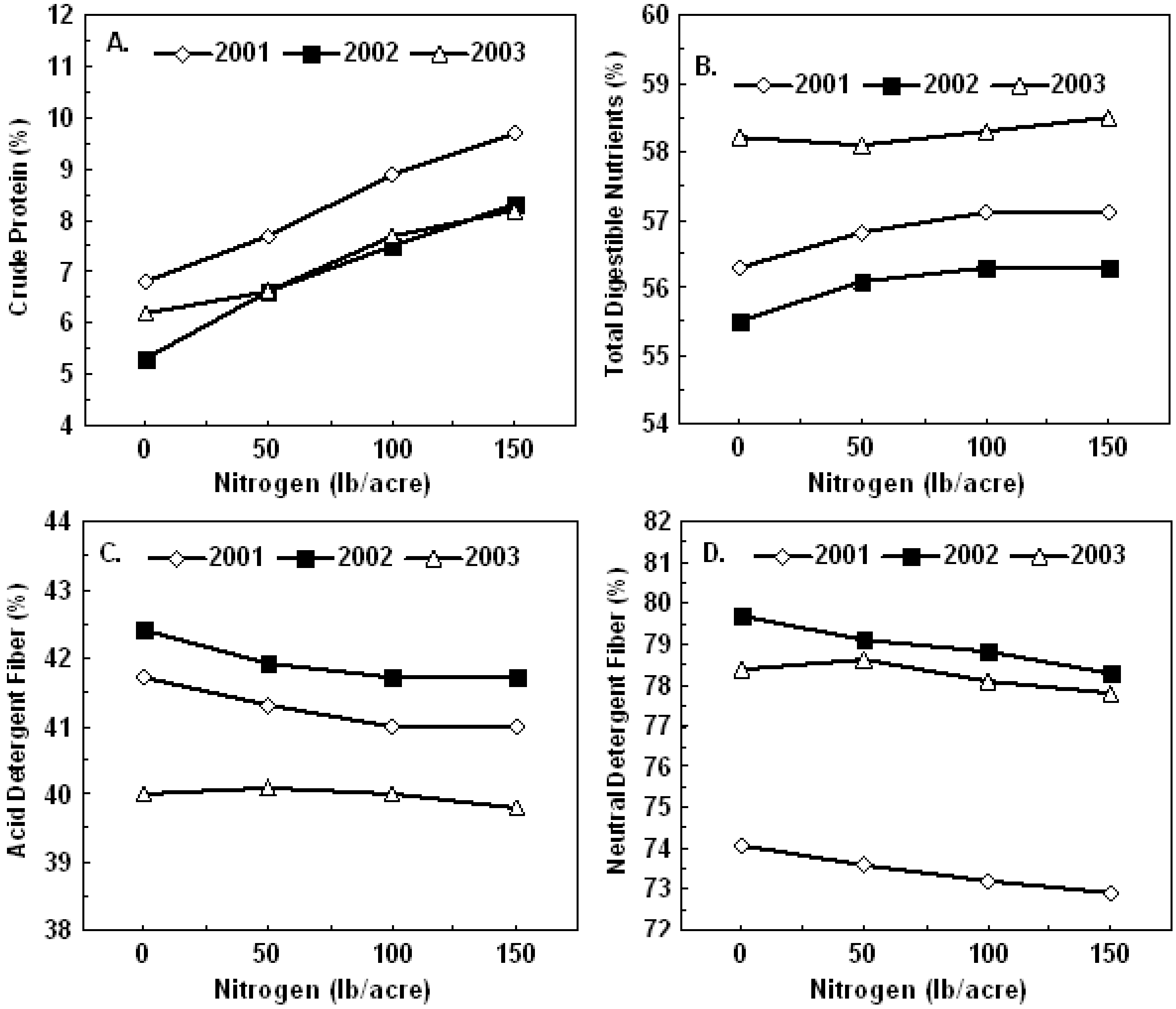

Fig. 3. Nitrogen fertilization rate effects on nutritive value of stockpiled bermudagrass near Burneyville, OK, 2001 to 2003: (**A**) crude protein; (**B**) total digestible nutrients; (**C**) acid detergent fiber; and (**D**) neutral detergent fiber. Values were computed across five nitrogen application dates, six harvest dates, and three replications (n = 90).

Harvest Date Effects

Nutrient concentrations often varied among harvest dates but overall exhibited small changes over the winter (Table 3). Crude protein differed as much as 0.7, 2.6, and 0.8 percentage points between successive harvest dates but changed by only 0.0, 0.5, and 1.0 percentage points from the first to the last harvest dates in 2001, 2002, and 2003, respectively. Total digestible nutrients varied as much as 1.8, 1.2, and 1.1 percentage points across successive harvest dates but declined by only 0.6, 1.5, and 0.9 percentage points from the first to last harvest dates in 2001, 2002, and 2003, respectively. Concentrations of ADF and NDF exhibited similar variability and small overall changes. Although nutritive value of fall stockpiled bermudagrass might be expected to steadily decline after a killing frost, variable weather patterns, altered leaf-to-stem ratios, growth of new tillers following periods of warm weather, and recruitment of cool-season annuals can contribute to inconsistent nutritive value responses (7,8).

Table 3. Year and harvest date effects on crude protein (CP), total digestible nutrients (TDN), acid detergent fiber (ADF), and neutral detergent fiber (NDF) of fall stockpiled bermudagrass in southern Oklahoma. Values were computed across four N rates, five N application dates, and three replications (n = 60; SEM = standard error).

Year		**Harvest Date**						
2001	**Nutrient**	**7 Dec**	**4 Jan**	**17 Jan**	**1 Feb**	**15 Feb**	**4 Mar**	**SEM**
	CP	8.5	8.4	7.7	8.3	8.3	8.5	.26
	TDN	56.7	57.3	56.4	56.5	57.9	56.1	.23
	ADF	41.4	40.8	41.6	41.5	40.3	41.9	.21
	NDF	76.6	74.1	74.4	72.7	71.5	71.4	.22
2002	**Nutrient**	**6 Dec**	**20 Dec**	**6 Jan**	**21 Jan**	**5 Feb**	**24 Feb**	**SEM**
	CP	5.9	7.5	6.9	8.7	6.1	6.4	.42
	TDN	56.0	57.0	56.4	56.8	55.7	54.5	.42
	ADF	42.0	41.1	41.6	41.2	42.3	43.3	.38
	NDF	77.4	79.0	79.2	79.5	79.5	79.4	.26
2003	**Nutrient**	**4 Dec**	**19 Dec**	**5 Jan**	**20 Jan**	**4 Feb**	**20 Feb**	**SEM**
	CP	8.1	7.3	6.7	6.9	6.8	7.1	.18
	TDN	58.6	59.6	58.5	57.9	57.4	57.7	.77
	ADF	39.7	38.8	39.7	40.3	40.8	40.5	.69
	NDF	74.5	80.4	79.6	79.3	78.3	77.2	.32

Nitrogen rate × harvest date and application date × harvest date interactions on CP in 2001 and 2003 resulted primarily from variability existing among harvest dates rather than variability in response to N fertilizer rate or N application date. Nutrient concentrations tended to respond positively to increased N fertilizer regardless of whether these effects were examined across harvest dates or by harvest date (*data not shown*). The lone exception was the harvest occurring on 20 January 2003 where unfertilized bermudagrass had the greatest CP.

Meeting Beef Cow Nutrient Needs

A 1200 lb, pregnant beef cow with 20 lb of peak milk production needs a diet of 24.1 lb DM/day, 6.2% CP (1.49 lb/day), and 46% TDN (11.1 lb/day) during mid-gestation (5). These requirements increase to 24.2 lb DM/day, 7.8% CP (1.88 lb/day), and 53% TDN (12.8 lb/day) during the last three months of pregnancy (5). The stockpiled bermudagrass would have met maintenance energy requirements during both of these periods regardless of N fertilization rates. On average across treatments, the bermudagrass provided 56% TDN (13.4 lb TDN/day). The ability of the stockpiled bermudagrass to meet maintenance protein requirements, however, would have depended on the N fertilization rate and the term of pregnancy. Across years, N application dates, and harvest dates, the stockpiled bermudagrass averaged 6.0, 6.9, 7.9, and 8.7% CP at 0, 50, 100, and 150 lb N per acre, respectively (1.47, 1.66, 1.91, and 2.10 lb CP/day). The unfertilized bermudagrass would have been deficient in CP regardless of the term of pregnancy. The fertilized bermudagrass would have met maintenance requirements for CP during mid-gestation regardless of N rate. During late gestation, however, only the bermudagrass fertilized with 100 to 150 lb N per acre would have met the CP requirements.

Nutrient concentrations were lower compared to other findings of fall-stockpiled bermudagrass. In Arkansas, fall-stockpiled bermudagrass had concentrations of CP, NDF, and ADF ranging from 12 to 25%, 43 to 76%, and 20 to 37%, respectively, depending on the location, stockpiling date, and harvest date (7). Concentrations of CP decreased from 14 to 13% and ADF increased from 31 to 40% over an October to February period in northeast Texas (1). Trials conducted at six sites across Oklahoma found CP concentrations in fall-stockpiled bermudagrass generally ranged from 10 to 15% (8). One site, however, reported a range of 6 to 9% CP, results that agreed with our findings. Although the location of our experiment differed, the similar range of 6 to 9% CP probably reflects that both trials contained 'Midland' bermudagrass on sandy loam soils.

Differences in nutrient concentrations and the degree that it changes over winter may also reflect cultivar and environment interactions. Crude protein changes over winter have been found to be positively associated with initial CP concentrations and forage maturity at first frost (1). Studies conducted in northern bermudagrass production areas also have shorter stockpiling periods than studies conducted in more southern production areas. Differences in moisture and temperature patterns may impact forage accumulation, maturity, and consequently, changes in nutritive value (4).

Conclusions

In years of favorable fall precipitation, producers can expect 4000 lb/acre of fall stockpiled bermudagrass forage with N applications of 50 lb/acre on sandy loam sites in southern Oklahoma. Stockpiled bermudagrass provided on average across treatments 56% TDN and 6.0, 6.9, 7.9, and 8.7% CP when fertilized with 0, 50, 100, and 150 lb N per acre, respectively. At these rates, the fertilized bermudagrass would have met maintenance requirements for energy and protein of mid-gestation beef cows. Nitrogen application date and harvest date did not dramatically affect fall forage accumulation or nutritive value.

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